Chapter 16
Ice-Related Hydrometeorological Data Collection and Monitoring

16-1. Introduction

Effective regulation of Corps water control and navigation projects requires the collection of a wide variety of real-time hydrometeorological data from field sites. There are reporting stations at each lock and dam. The data can be manually obtained by the lock and dam staff, or can be obtained using Data Collection Platforms (DCPs) via the GOES (Geostationary Observational Environmental Satellite) near real-time data collection system. (GOES is operated by the National Oceanic and Atmospheric Administration [NOAA].) Downlinks are in operation throughout the northern latitudes at the New England District, the Ohio River Regional Headquarters of the Great Lakes and Ohio River Division, the Rock Island District, and the Missouri River Regional Headquarters and North Pacific Regional Headquarters of the Northwestern Division. These downlinks enable each Division and District to collect data from field sites at intervals of 4 to 24 hours. The data are checked for completeness before they are stored in dedicated water control computers and are available for analysis by all Corps personnel. ER 1110-2-248 provides for Corps policy when using the GOES data collection system. Ice conditions can also be monitored using aircraft and satellites; video and still photographs are often used to track ice conditions along navigable waterways. A schematic of a systems approach to data collection and distribution is shown in Figure 16-1.

Section I
Numerical Data

16-2. Near Real-Time Data Collection

Ice information can be obtained in near real-time using the GOES data collection system. Each Corps office, per ER 1110-2-249, has a Water Control Data System (WCDS) that meets the requirements of automated near real-time data collection, processing, and dissemination for making near real-time water control decisions. A GOES data collection system is made up of four parts: the DCP with related sensors, the GOES satellite, the direct ground readout station, and the WCDS. Authorization to use the GOES system is required, and software for processing and dissemination of ice information is necessary for the use of this system in a river ice management scheme.

16-3. DCP System

The instrumentation requirements for ice monitoring, as in any engineering study, are defined by the kind and accuracy of measurements required and the frequency of data collection necessary. Existing ice forecasting models use the temperature-index approach to predict the onset and breakup of river ice.

a. Temperature-index approach. The temperature-index approach requires water temperature and air temperature data. These are the minimum requirements for an ice monitoring station. This information, in the absence of a forecast model, could be used by the lockmaster to determine operating criteria. The other extreme would be using an energy-balance model to forecast ice conditions. The energy-balance approach would require other hydrometeorological data in addition to water and air temperatures, such as wind speed and direction, solar radiation, and river stage. Table 16-1 shows the parameters to be measured at both the temperature-index and energy-balance types of stations, as well as their resolution and accuracy requirements. The DCP and sensors selected should have the capability to

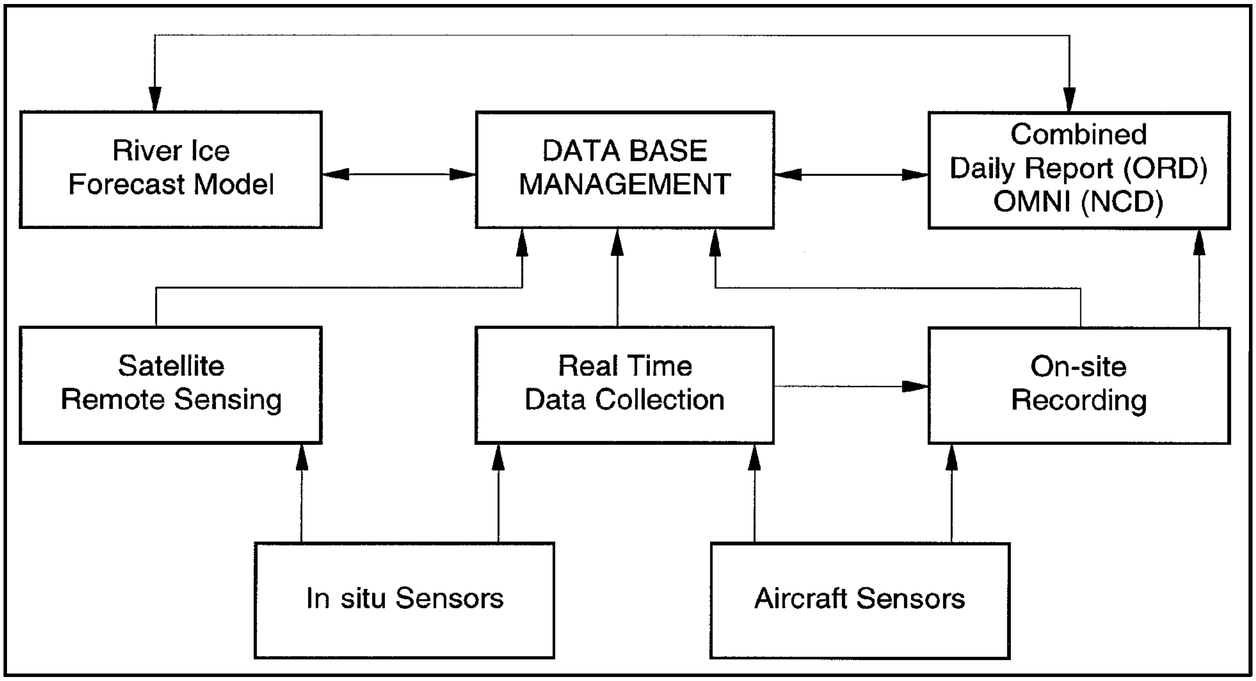


Figure 16-1. Schematic of data collection system for ice information

Table 16-1
Parameters for Ice-monitoring DCP Sites

Parameter	Resolution	Accuracy
Water temperature	0.1 °C (0.2 °F)	±0.1 °C (±0.2 °F)
Air temperature	0.5 °C (1 °F)	±0.5 °C (±1 °F)
Wind speed	0.3 m/s (1 ft/s)	±5%
Wind direction	10°	±5°
Solar radiation	10 W/m^2 (1 W/ft^2)	±10 W/m^2 (±1 W/ft^2)
Barometric pressure	3 mb (0.1 in. Hg)	±3 mb (±0.1 in. Hg)
Relative humidity	5%	±5%
Precipitation	0.2 mm (0.01 in.)	±0.2 mm (±0.01 in.)
River stage	0.003 m (0.01 ft)	±0.003 m (±0.01 ft)
Dam gate setting	0.15 m (0.5 ft)	±0.15 m (±0.5 ft)
Ice thickness	0.03 m (0.1 ft)	±0.03 m (±0.1 ft)

supply the given resolution and accuracy. The need for high resolution and accuracy in water temperature measurement cannot be overemphasized, particularly when such data are inputs to an Ice Forecasting System.

b. Average daily temperature. Normally, for the temperature-index approach to ice forecasting, a daily average air temperature and a daily average water temperature are used. To best calculate a daily average of these values, data should be collected every hour. This also holds for the energy-balance approach. Based on the amount of data to be transmitted, a 4-hour transmission interval is best.

16-4. Water Temperature Measurements

A system developed for remote, accurate river water temperature measurements can be installed at any facility where a water-temperature probe can be properly mounted in contact with the flowing river water. The data can be recorded on a data logger or transmitted by a DCP through the GOES system. Described below are the water temperature measurement system itself and the method of installing it, interfacing the system with a DCP or data logger for recording the water temperature measurements, and reducing the information to engineering units.

a. Description. This water temperature measurement system consists of a water-temperature probe, a probe support pipe with probe adaptor, connecting cable, and a data logger or DCP (Figure 16-2). If a DCP is used, a special interface is needed for the probe.

b. Water-temperature probe. The water-temperature probe is a 0.9-meter (3-foot) length of stainless steel tube with an 2.5-centimeter (1-inch) outside diameter (Figure 16-3). The lower tip of the probe is nylon and contains three thermistors. A cable grip attaches the water-temperature probe to the cable at its upper end. The water-temperature probe is deployed by dropping it down the probe support pipe and seating it in the probe adaptor. The probe is designed both to protect the thermistors from being hit by debris while allowing them to directly contact the water and to be conveniently removable for repair or replacement. The cable connected to the water-temperature probe does two jobs: it provides electrical connection to the thermistor, and it is used to place or remove the probe by hand.

c. Thermistors. The thermistors in the probe are typically of the bead-in-glass type and are suitable for immersion in water. The thermistors are individually spliced into the cable. Each splice must be individually tested for electrical and mechanical integrity and to make sure that it is waterproof. A strain relief device attached to the nylon tip prevents any strain from being applied directly to the thermistors. Depending on the application, the thermistors can be calibrated individually or as a group.

d. Probe support pipe and probe adaptor. The probe support pipe protects the probe from debris or ice, holds the probe, and provides an easy way for the probe to be installed and removed. At the lower end of the probe support pipe is the probe adaptor (Figure 16-2). The adaptor has one Teflon or nylon ring that cradles the probe and holds it in position (Figure 16-3). The probe support pipe is 3.2-centimeter (1-1/4-inch) schedule 80 galvanized steel pipe with couplings. Installation of the probe support pipe and adaptor is discussed in subparagraph 16-4*i*(1) below.

e. Connector box. At the upper end of the probe support pipe is a connector box (Figure 16-4) that provides easy access for placing or removing the water-temperature probe. A water-resistant electrical connector attaches the cable to the water-temperature probe and the cable to the data logger or DCP. The connector box is typically a 3.2-centimeter (1-1/4-inch) Line Back (LB) conduit box (zinc electroplate with aluminum lacquer), with a water-resistant neoprene-gasketted cover, and bushings to connect with the probe support pipe and conduit.

f. Conduit. A 1.9-centimeter (3/4-inch) conduit protects the cable running from the connector box to the location of the DCP or data logger. In many instances existing cableways can be used. If new conduit is installed, provision for pull boxes at appropriate intervals must be made.

g. Cable. The cable used to connect the temperature probe and the electrical connector in the connector box must be rugged. A petrolatum-polyethylene gel-filled cable with a polyethylene jacket is recommended. The cable should have a solid copper tape shield with three-pair 19-AWG conductors.

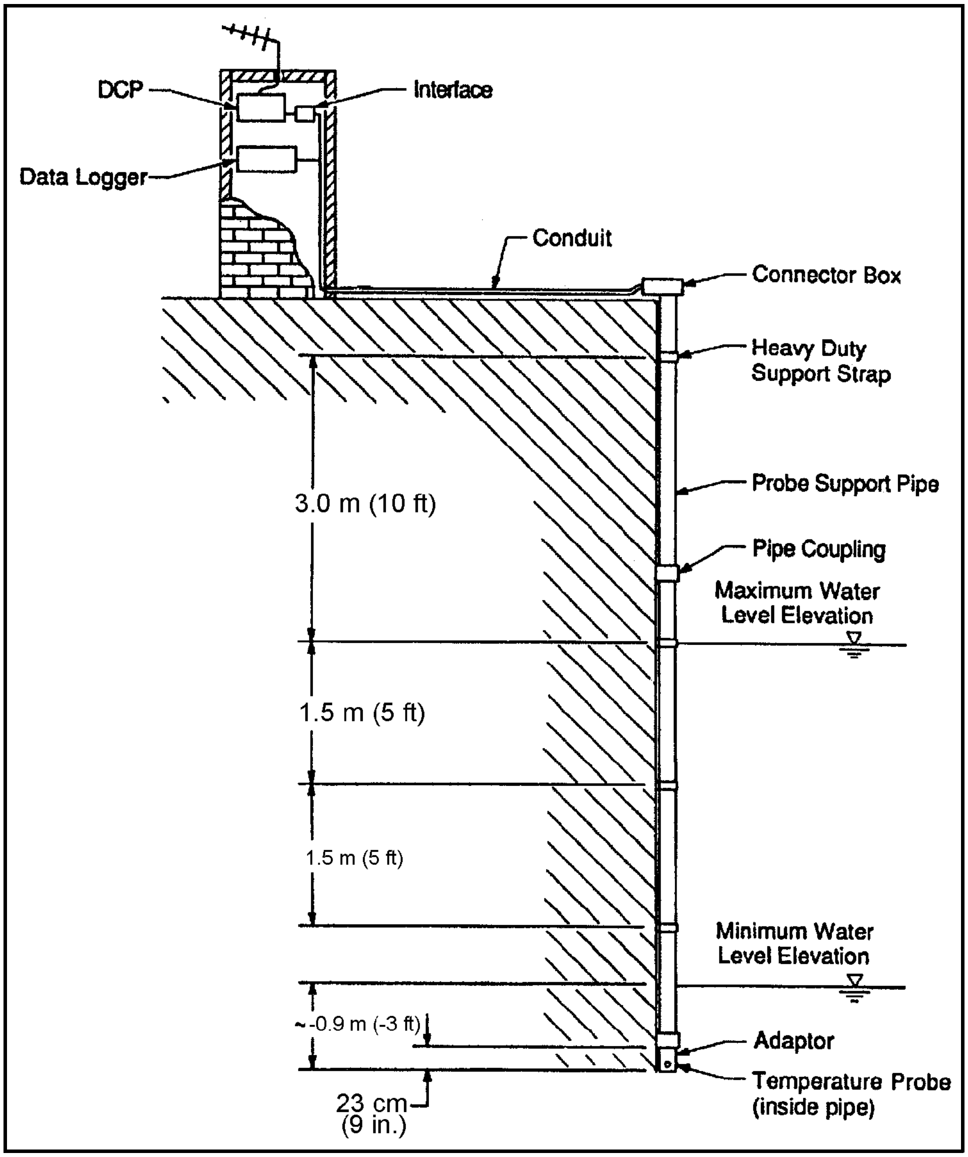


Figure 16-2. Water-temperature measurement system

This type of cable is relatively inexpensive and will provide long life. The cable is stiff and can be used only for straight runs or wide sweeps. A wire cable support grip may be attached to the upper end of the cable to assist in placing or removing the water-temperature probe. To hook up the electrical connectors in the connector box and the interface box, a cable with three 18-AWG, twisted, shielded pairs with drain wire is recommended. The cable should have a polyvinyl chloride (PVC) outer jacket. This type of cable is more flexible than the gel-filled cable and can easily be pulled through the recommended conduit. This cable has also been used to connect the temperature probe and the electrical connector in the connector box with success.

h. DCP Interface. Generally, a DCP can measure only voltages. Thermistors, however, change resistance in response to changing temperature. The DCP interface, therefore, is a simple voltage divider circuit that converts the thermistor resistance to a voltage. The interface is a rectangular box, 5.7 × 5.7 × 12.7 centimeters (2-1/4 × 2-1/4 × 5 inches), that is typically installed immediately adjacent to the DCP.

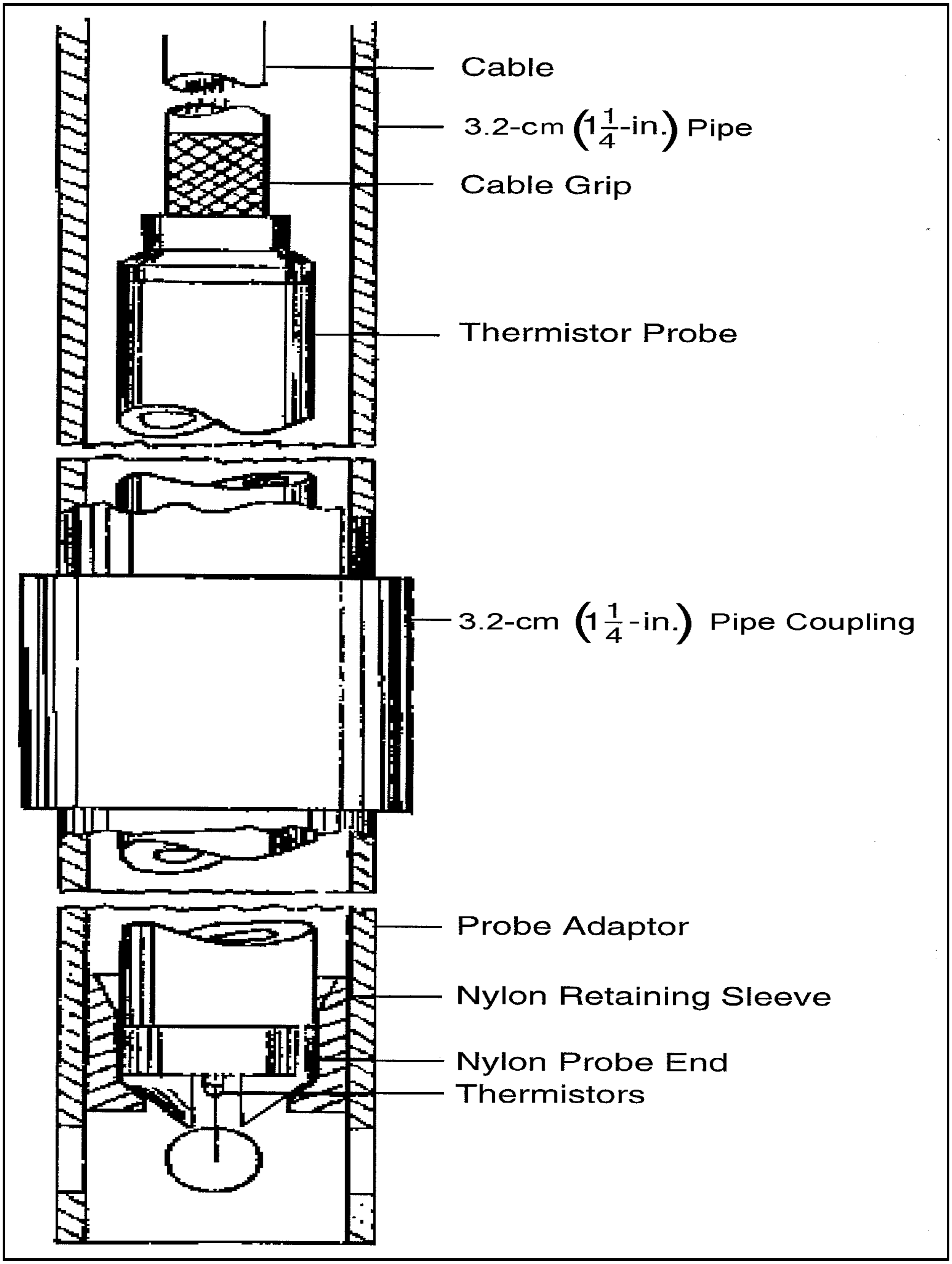


Figure 16-3. Water-temperature probe within the probe adaptor

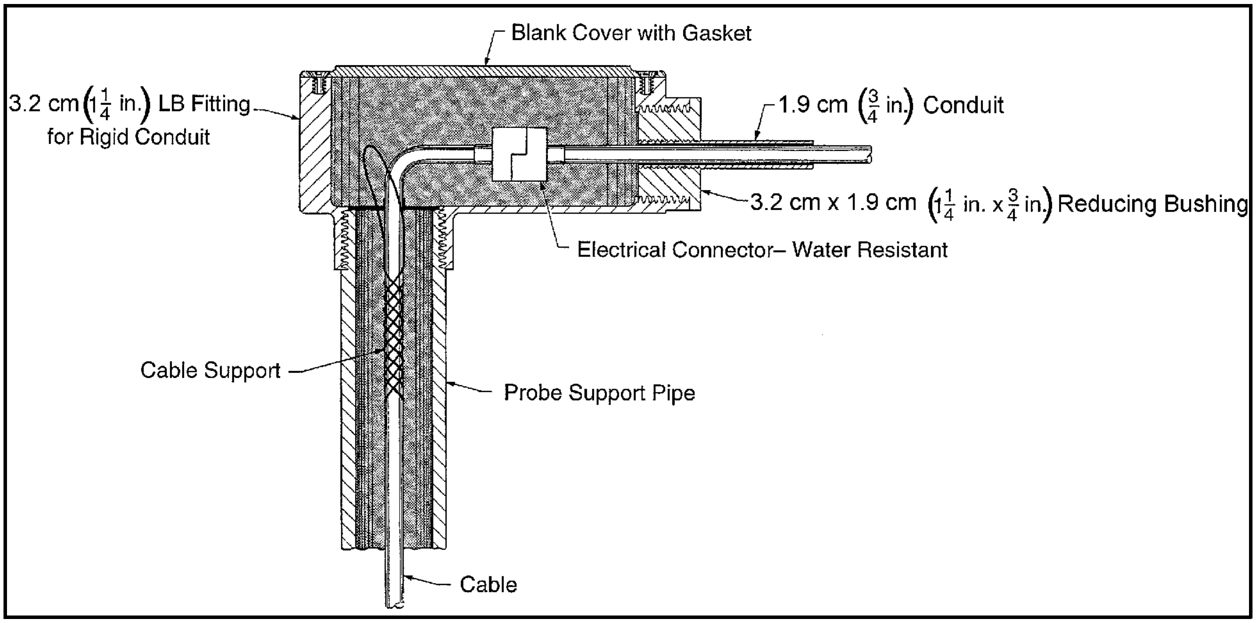


Figure 16-4. Connector box

Figure 16-5 shows a schematic diagram of the wiring of the interface box and the connections to the temperature probe and the DCP. The resistance of a thermistor R_i can be determined by the relation

$$R_i = (10{,}000)\frac{V_i}{V_o - V_i}$$

where V_i is the measured voltage across the thermistor, and V_o is the excitation voltage applied to the divider circuit. The applied voltage across the thermistor is kept low by the use of a diode. This is done to keep the electrical current in the thermistor to a minimum to prevent self-heating. The relatively large offset currents that may be introduced into the voltage divider circuits by the circuitry of the DCP itself result in an inaccurate voltage measurement across the thermistor. To correct for this, the voltage across a reference resistor, with a known stable resistance, is measured along with the voltage across the thermistor. The measured voltage across the reference resistor V_f can then be used to calculate each thermistor's resistance by

$$R_i = \frac{(10{,}000)\,V_i}{2V_f - V_i}$$

As an example, for V_i = 0.219 volts and V_f = 0.294 volts, the resistance of the thermistor of the water-temperature probe R_i is calculated by the above equation to be 5935 ohms. Suppose the calibration table for this particular thermistor is in degrees Celsius and gives 5951.3 ohms for 0.1°C and 5919.1 ohms for 0.2°C. Then, by interpolation the water temperature would be determined to be 0.15°C or 32.27°F. The foregoing discussion addresses some of the potential problems in interfacing input parameter signals to a DCP. In all cases the DCP manufacturer's input and output impedance specifications must be known and considered by competent electronics personnel for the proper design of the DCP interface box, thus ensuring a trouble-free overall installation.

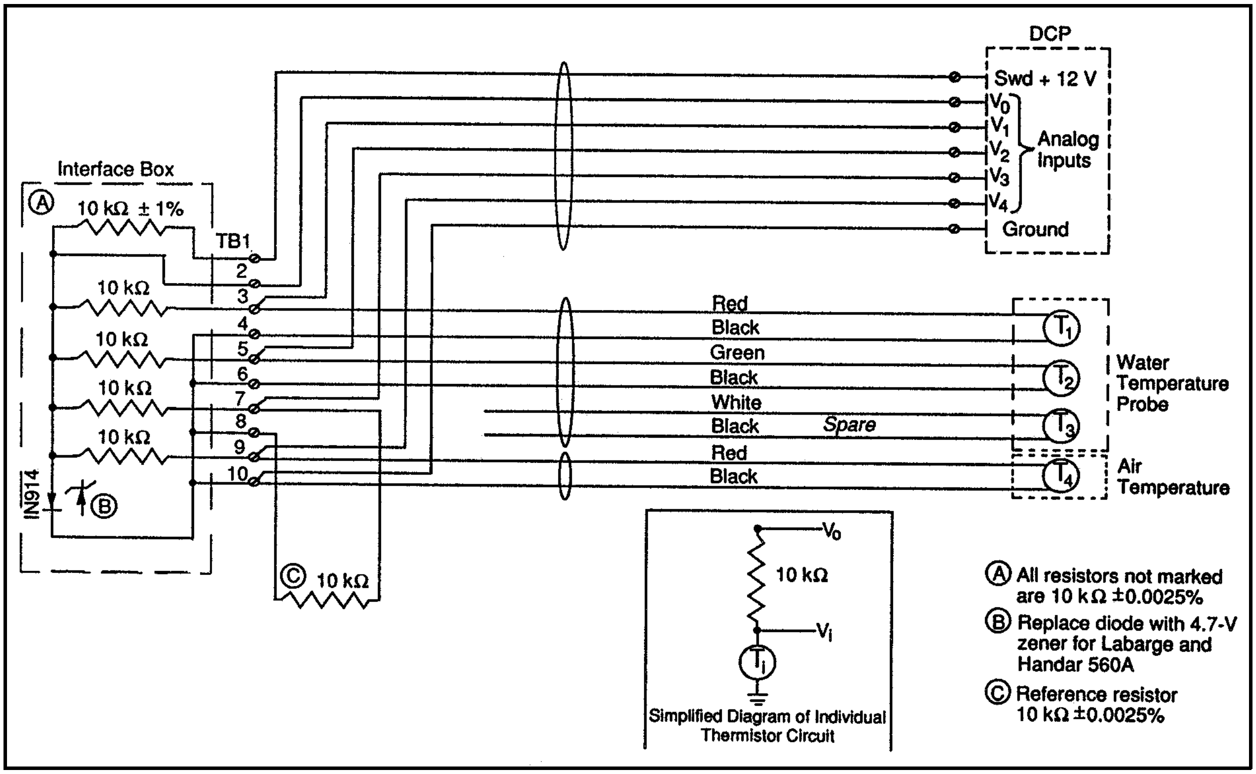


Figure 16-5. Schematic wiring diagram of DCP interface box

i. Installation. There are five steps in the installation of this water-temperature measurement system: selection of location, determination of minimum water surface elevation, installation of probe support pipe and adaptor, installation of the connector box and conduit, and installation of the data logger or DCP.

(1) Selection of location. The probe support pipe is typically installed on a wall or pier. The probe support pipe must be installed so that it is in contact with the moving river water. It should not be placed in gage wells, locks, or other areas where the water may stand for long periods. It should be placed in a protected location, if possible, so that it is safe from drift and ice floes. The downstream side of piers, cells, piles, pile dolphins, ladder accessways, and recesses in walls parallel to the river are acceptable.

(2) Determination of minimum water level elevation. River water level elevations or stages can change rapidly and can vary considerably. The difference between low flow levels and flood levels may be 12 to 24 meters (40 to 60 feet) in some locations. The minimum and maximum stage possible at a given site must be taken into account before installation. An estimate of the minimum must be made to ensure that the stage does not fall below the elevation of the water-temperature probe. If this happens, water temperature measurement will obviously not be possible. The bottom of the adaptor must be a minimum of 0.9 meters (3 feet) below the lowest stage expected. If very thick ice is expected, the adaptor should be placed even lower to keep the water-temperature probe in flowing water. The connector box should be above the normal seasonal high water levels.

(3) Installation of probe support pipe and adaptor. The probe support pipe must be installed vertically to allow the water-temperature probe to be lowered and removed easily. The length of pipe should be determined as follows: Measure the distance from the top of the wall to a point 0.9 meters (3 feet) below

the low water level elevation at the site. Subtract 0.15 meters (6 inches) from this distance. This will be the total length of schedule 80 pipe plus couplings that will be required. This will bring the top of the schedule 80 pipe 7.6 centimeters (3 inches) above the top of the wall, which is the correct height for the connector box. The required number of sections of the galvanized steel pipe are fastened together with couplings to form the probe support pipe. The adaptor is fastened on the lower end of the probe support pipe with a coupling. All couplings are tightened using a 0.6-meter (24-inch) pipe wrench to ensure that the entire probe support pipe and adaptor are securely fastened. The probe support pipe with the adaptor is raised into position by a crane or other means. Heavy-duty stainless steel straps are fastened at regular intervals with 1.3-centimeter (½-inch) Hilti quick studs or equivalent along the probe support pipe to hold it in position, again, with the bottom of the adaptor 0.9 meters (3 feet) below the lowest water level expected. The straps should be spaced using a maximum 1.5-meter (5-foot) interval up to the maximum water level elevation. Above the maximum water level elevation, a maximum spacing of 3 meters (10 feet) is allowable. The plumb of the probe support pipe should be checked continuously to make sure that the pipe remains completely vertical during installation. Otherwise, problems could occur with future probe removal or reinstallation.

(4) Installation of connector box and conduit. The connector box is threaded onto the probe support pipe. The connector box should be mounted such that the water-temperature probe can be placed in the probe support pipe through the top of the connector box with the cover plate removed. The connector box should be 7.6 centimeters (3 inches) above the wall so that it can be seen during snow removal. A reducing bushing is installed in the end of the connector box to adapt it to 1.9-centimeter (3/4-inch) conduit. Conduit is installed from the connector box to the point of data collection, with provisions for pull boxes where required.

(5) Installation of the data logger or DCP. The data logger or DCP is connected (Figure 16-5) to the interface box. Analog inputs to DCPs with scaling resistors should be avoided or the scaling resistors should be removed. If a data logger is used, a 12-volt-dc power supply must be provided. For consistency, the connections with the interface box should be in the order indicated.

16-5. GOES Satellite—WRSC Authorization

The Water Resources Support Center, Data Collection and Management Division (WRSC-C), has the responsibility and is the focal point for the U.S. Army Corps of Engineers Civil Works for call sign and radio frequency management.

16-6. Direct Ground Readout Station

The GOES system can only be used to relay environmental data. In situ data from any sensor that can be interfaced to the data collection platform can be telemetered to District offices. All the data transmitters that use the GOES/DCS must be certified by the National Oceanic and Atmospheric Administration, National Environmental Satellite Service. See ER 1110-2-248 for further instructions.

16-7. Water Control Data System (WCDS)

The receiving sites at the Corps offices are usually a part of the WCDS. Guidance for the management of dedicated water control data systems (including equipment and software used for the acquisition, transmission, and processing of real-time data for the purpose of regulating water projects that are the Corps' responsibility) can be found in ER 1110-2-249.

Section II
Imagery

16-8. Introduction

A necessary part of an ice management program is having adequate information on ice conditions. Corps Districts generally have one or both of the following objectives when documenting ice conditions as part of their river ice management activities: to analyze past ice conditions as an aid in forecasting future conditions during a given winter, and to monitor current conditions during a winter in sufficient detail so as to plan waterway operations and anticipate navigation problems.

a. Ice conditions information sources. The first objective can be accomplished using historical ground observations, aerial photographs, and satellite images. However, the most common District need is for monitoring current ice conditions along all their navigable waterways. At most navigation projects, Corps personnel already make ice observations and report them to District offices nearly every day during the winter season. The data are then available to users via computer modem. However, these ground observations are pertinent only for that portion of a waterway within sight of the observers. Ice conditions beyond that are uncertain, and yet such data for the entire waterway are required. Satellite images from current civilian satellites, which do show entire waterways, have neither the spatial resolution nor can they routinely be in the hands of District personnel quickly enough to enable decision-making regarding waterway operations or ice emergencies (Gatto et al. 1987a; Gatto 1988a, 1988b). As satellite sensors and image processing systems improve, future images may be provided rapidly enough and may be of sufficient resolution to be useful.

b. Current ice conditions. Aerial photographs and videotapes can currently provide timely ice information to meet the second objective above, i.e., monitoring current conditions (Gatto et al. 1986, 1987b). The acquisition of ice data from these two sources is the subject of the remainder of this chapter. Taking photographs is the best approach when it is only ice conditions at selected locations that must be documented. When continuous bank-to-bank coverage of ice conditions over large reaches of a waterway is required, vertical (downward-looking) aerial videotapes are most useful. Oblique videotaping can be done through an aircraft window, but this is awkward and uncomfortable for the videographer for extended periods, and complete bank-to-bank coverage is often difficult to obtain over large river reaches. Table 16-2 provides information comparing hand-held aerial photography and aerial videotaping.

16-9. Aerial Photography by Hand-Held Camera

Many photographic formats, film types, and cameras are available for taking aerial photographs. However, one of the least expensive and most useful formats is hand-held 35-mm oblique photography, producing slides or prints taken during low-altitude aircraft flights. The use of 35-mm photos for documenting general ice conditions and evaluating potential problem areas, e.g., ice jam sites, heavy ice, etc., is very appropriate when cartographic precision and photogrammetric quality are not required (Gatto and Daly 1986). Such photographs are simple and inexpensive to acquire and most people are familiar with them, as compared to other more elaborate aerial photographs.

a. Crew. The number of people required to get the photographs will vary depending on the complexity of the mission. When a few photographs of a small area are needed, one person can take them, even if that person is the pilot. A more complex mission would require three people including the pilot.

Table 16-2
Two Methods for Monitoring Ice Conditions on Navigable Waterways

Method	Equipment	Costs*	Advantages	Disadvantages
Hand-held aerial photographs	35 mm camera Color film for slides or prints Maps for locating photos in flight Fixed-wing aircraft** (e.g., Cessna 172)	$300 $3–$8/roll for slides, $7 for prints $1.50 each $60–$80/hr	Good resolution Different films can be used Low costs, once initial purchases are made Supplies and equipment readily available Camera systems are portable and flexible No extensive training required; most everyone is familiar with cameras Photographer can select targets	Can't take photos during inclement weather Takes a few hours to get slides or prints Ice thickness not obtainable; best guess only Snow-cover obscures ice Quality of photos unknown until they are developed
Aerial videotapes	Camera for ½ in. VHS or Beta, 3/4 in. U-matic On-board monitor Video recorders Camcorder (VHS) High grade color videotapes (T-120) Maps for locating tapes in flight Fixed-wing aircraft** (e.g., Cessna 172)	$1200–$5000 $ 600 $2500 (½ in.), $5000 (3/4 in.) $1600–$2200 $7/tape $1.50 each $60–$80/hr	Continuous view of river Immediate availability of tapes Operator sees image during acquisition; could correct problems in flight Low cost No extensive training required; familiar to many people Playback technology widely available Can get slides and prints from tapes Supplies and equipment readily available Tapes can be reused Videographer can select targets, if taking obliquely	Lower resolution than photographs but sufficient to differentiate ice types Can't take tapes during inclement weather Ice thickness not obtainable; best guess only Snow-cover obscures ice

* Costs will vary; these are simply estimates (1988 dollars).
** Helicopters can be used but cost more per hour.

One person would act as navigator to check items on the mission plan, direct the pilot to sites, take notes of sites photographed, change film, etc. The photographer would devote full time to taking pictures.

b. Mission plan.

(1) The photographer and navigator should prepare a general mission plan and discuss the plan and flight objectives with the pilot before a flight (Shafer and Degler 1986). They should discuss the features to be photographed and devise a way to communicate to let the pilot know when pictures are being taken. The pilot can then make a special effort to minimize motion and provide a good view of the area to be photographed. A professional pilot, with or without remote sensing experience, can contribute significantly by understanding what the flight objectives are.

(2) Mission planning will also permit more accurate estimates of materials needed, flight time, and overall costs for the mission. A mission plan should include a list of prospective targets and film requirements, maps marked with the most economical flight path, and a checklist of equipment, including extra batteries, lens caps, battery chargers, extra film, filters, etc. The maps help to avoid unnecessary

circling and the resulting questions regarding whether a particular site has been photographed or not. When maps are used in flight, a lapboard serves as a convenient writing surface.

c. Equipment (Shafer and Degler 1986). A 35-mm camera with a built-in automatic light meter and a standard (50-mm) lens is the minimum equipment needed. Optional but useful equipment includes a zoom lens, motor drive, data and magazine backs, and filters. The configuration of a camera system depends upon budget and photographic requirements.

(1) Either a single lens reflex (SLR) or rangefinder camera can be used effectively. With a rangefinder camera, the photographer must be aware that a clear shot through the rangefinder does not assure that the camera's field of view will not be partially blocked by part of the aircraft. With an SLR, what is seen is literally what is photographed. In difficult lighting situations where there is glare from aircraft windows, the SLR makes the photographer aware of potential problems so a correction for glare can be made during the flight.

(2) Regardless of what length of lens is used, it should be a relatively "fast" one (i.e, capable of admitting adequate light at higher shutter speeds) to avoid any loss of definition resulting from aircraft vibration. A zoom lens is useful because it allows the photographer to rapidly change for wide-angle and narrow-angle (more detailed) pictures.

(3) A motor drive permits obtaining several good exposures of a site during one pass. By simplifying the operation of the equipment, it also encourages the photographer to focus attention on the sites being evaluated, rather than concentrating on camera operation.

(4) Because of the high cost of aircraft rentals and the relatively low costs of film and processing, it makes sense to take a large number of pictures. However, labeling and sorting them is a chore at best. Data backs are particularly useful in recording the time and date, saving considerable time and effort later. Magazine backs (for up to 250 pictures) eliminate the need to change film frequently. They provide continuity during a flight and reduce the chance of error in numbering sequential rolls of film. They also permit the photographer to take many pictures with a minimum of costly time spent changing film. However, processing of long rolls (in excess of 36 exposures) must be done by a specialty lab. If a magazine back is not used, a second camera is a good investment. The navigator can reload one camera while the photographer is using the other.

(5) Regular true color film for slides (e.g., Ektachrome) and prints (e.g., Kodacolor) works fine for most conditions. A relatively fast film (ASA 100 or higher) with a fine grain is best.

(6) As a matter of course, clear filters should be on all lenses to protect them from dirt and damage. A polarizing filter may be used successfully with most films; however, the combination of a polarizing filter and the aircraft window may produce a wavy pattern on a picture. Usually, a polarizing filter improves the quality of photographs taken where reflections from water produce glare.

d. Taking photographs (Evans and Mata 1984). Aerial 35-mm pictures may be taken nearly vertically or obliquely out the window of a small, fixed-wing aircraft or helicopter. Shutter speeds should be 1/500th of a second or faster. An altitude of 450 meters (1500 feet) above the ground is recommended, but any altitude must be consistent with local Federal Aviation Administration regulations. If possible, shoot with the window open. This eliminates glare and reflection caused by the glass. If you have to shoot through the window, use an 81A filter, or an equivalent haze filter, to compensate for the slight blue-green tint inherent in the acrylic glass used in most light airplane windows. Also, wear a long-sleeved dark shirt or jacket to reduce the chance of creating unwanted window reflections. Always use a lens shade. Window glare can often be eliminated by moving the lens slightly closer to the window or by draping the photographer and camera with a jacket or blanket to stop light passing over the photographer's shoulder. With a high-wing aircraft, the best shooting angles are in front of and behind the wing-struts. The front angle is best for tracking a subject, if care is taken to avoid getting the propeller in the frame. With a mid- or low-wing plane, pictures may have to be taken in a steep turn to avoid photographing the wing.

(1) A hand-held camera can take stereo pairs by photographing two successive images framed to get the same location. The movement of the aircraft between exposures will produce the parallax necessary for stereo viewing. The stereo effect will show the surface roughness of the ice, and this three-dimensional view is more realistic and easier to relate to actual visual observation. Panoramic mosaics of reaches of a river can also be made by taking as many successive photographs as required to cover the area of interest. Be sure to overlap successive photos enough to get complete coverage of the area. Note that the overlap areas will be in stereo.

(2) If repetitive photographs are going to be taken during different flights over periods of days, weeks, or months, the comparison of photos from the several flights will be easier if the same camera, focal length lens, filters, etc., are used each time. Taking photos from the same general position, and showing the same ground area, will also expedite comparisons of repetitive photos. Such repetitive photos give a visual time series of ice conditions, and are useful for determining how conditions are changing.

e. Photointerpretation. An advantage of using hand-held aerial photographs is that almost everyone has taken them and looked at, i.e., "interpreted," them. No special equipment is required to study the photos. The most important element for interpreting photos of ice conditions is to have a person familiar with river ice involved in the interpretation.

16-10. Aerial Videotapes

Aerial videotapes are more convenient to take than overlapping hand-held photographs if continuous coverage of a waterway is required and are less expensive than vertical 23 × 23-centimeter (9 × 9-inch) aerial photographs. Such continuous coverage can be acquired with a video camera mounted to look through the nose or out the side door of a helicopter, or through a belly port of a fixed-wing aircraft.

a. Crew. Since videotaping will generally be used to get continuous coverage, a pilot and videographer are all that is required. A navigator is not required because all of a waterway is going to be covered and site selection and spotting are not done. The pilot should be familiar with techniques for maintaining a flight course so as to get complete coverage while keeping the video camera in a vertical or near-vertical position. The videographer will have to use a zoom lens and tell the pilot when altitude adjustments are required to maintain bank-to-bank coverage.

b. Mission plan (Maggio and Baker 1988). Just as when acquiring hand-held aerial photographs, careful mission planning must be done to get useful videotapes. It is important to keep in mind that bank-to-bank coverage should be maintained while videotapes are being taken. This will allow easy locating later by comparing features on the tapes with those on maps. Widths of the waterway to be taped should be used to determine the flying heights and focal lengths required to provide bank-to-bank coverage and to determine the maximum aircraft speed to avoid image blur caused by forward image motion and aircraft vibration (see Table 16-3).

Table 16-3
Aerial Video Coverage Versus Pixel (Picture Element) Size, Altitude, and Aircraft Speed (Based on 2/3-inch Video Format)

SI Units

Coverage (m)		Effective Pixel Size* (m)	Altitude (Feet Above Ground) Required for Various Lens Focal Lengths					Maxmum Aircraft Speed** (km/h)
Width	Length		6.0 mm	8.5 mm	12.5 mm	16.0 mm	25.0 mm	
152	114	0.6	104	147	216	277	433	101
305	229	1.2	208	294	433	554	866	203
457	343	1.8	312	442	650	831	1,299	304
610	457	2.4	416	589	866	1,108	1,732	406
762	572	3.0	520	736	1,082	1,385	2,165	507
914	686	3.7	623	883	1,299	1,663	2,598	610
1,067	800	4.3	727	1,031	1,515	1,940	3,031	711
1,219	914	4.9	831	1,178	1,732	2,217	3,464	813
1,524	1,143	6.1	1,039	1,472	2,165	2,771	4,330	1,015
1,829	1,372	7.0	1,247	1,766	2,598	3,325	5,195	1,218
2,134	1,600	8.2	1,455	2,061	3,031	3,879	6,061	1,421
2,438	1,829	9.4	1,663	2,355	3,464	4,433	6,927	1,624
3,048	2,286	12	2,078	2,944	4,330	5,542	8,659	2,031
3,658	2,743	14	2,494	3,533	5,195	6,650	10,391	2,437

English Units

Coverage (ft)		Effective Pixel Size* (ft)	Altitude (Feet Above Ground) Required for Various Lens Focal Lengths					Maxmum Aircraft Speed** (knots)
Width	Length		6.0 mm	8.5 mm	12.5 mm	16.0 mm	25.0 mm	
500	375	2	341	483	710	909	1,420	55
1,000	750	4	682	966	1,420	1,818	2,841	109
1,500	1,125	6	1,023	1,449	2,131	2,727	4,261	164
2,000	1,500	8	1,364	1,932	2,841	3,636	5,682	219
2,500	1,875	10	1,705	2,415	3,551	4,545	7,102	274
3,000	2,250	12	2,045	2,898	4,261	5,455	8,523	329
3,500	2,625	14	2,386	3,381	4,972	6,364	9,943	384
4,000	3,000	16	2,727	3,864	5,682	7,273	11,364	439
5,000	3,700	20	3,409	4,830	7,102	9,091	14,205	548
6,000	4,500	23	4,091	5,795	8,523	10,909	17,045	658
7,000	5,250	27	4,773	6,761	9,943	12,727	19,886	767
8,000	6,000	31	5,455	7,727	11,364	14,545	22,727	877
10,000	7,500	39	6,818	9,659	14,205	18,182	28,409	1,097
12,000	9,000	47	8,182	11,591	17,045	21,818	34,091	1,316

* Effective pixel size based on 258 pixels per format width.
** To avoid forward image motion blur if not using shuttered camera or forward image compensation.

c. Equipment (Meisner and Lindstrom 1985, Meisner 1986). The type and setup of videotaping equipment (Figure 16-6) used to get vertical videotapes from an aircraft will depend on cost and requirements. Numerous cameras and recorders exist, and technology is improving constantly, but whatever kind of system is used, it should be professional-grade, compact, and built to take abuse, and should provide high quality video. Camcorders combine video cameras and recorders in one unit and also provide high quality tapes.

(1) The audio track of the airborne Video Cassette Recorder (VCR) may be connected to a “press to talk” microphone, allowing oral comments to augment written notes during flight. In particular, landmarks and locations should be called out. A soundproof headphone intercom system used in the aircraft can be directly connected to the VCR audio input.

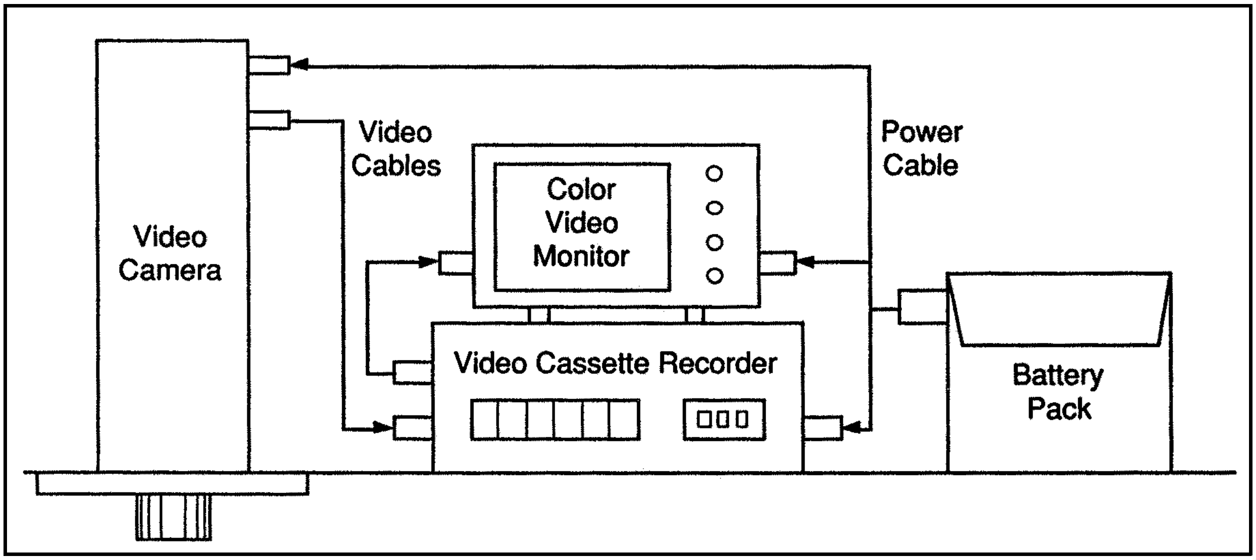


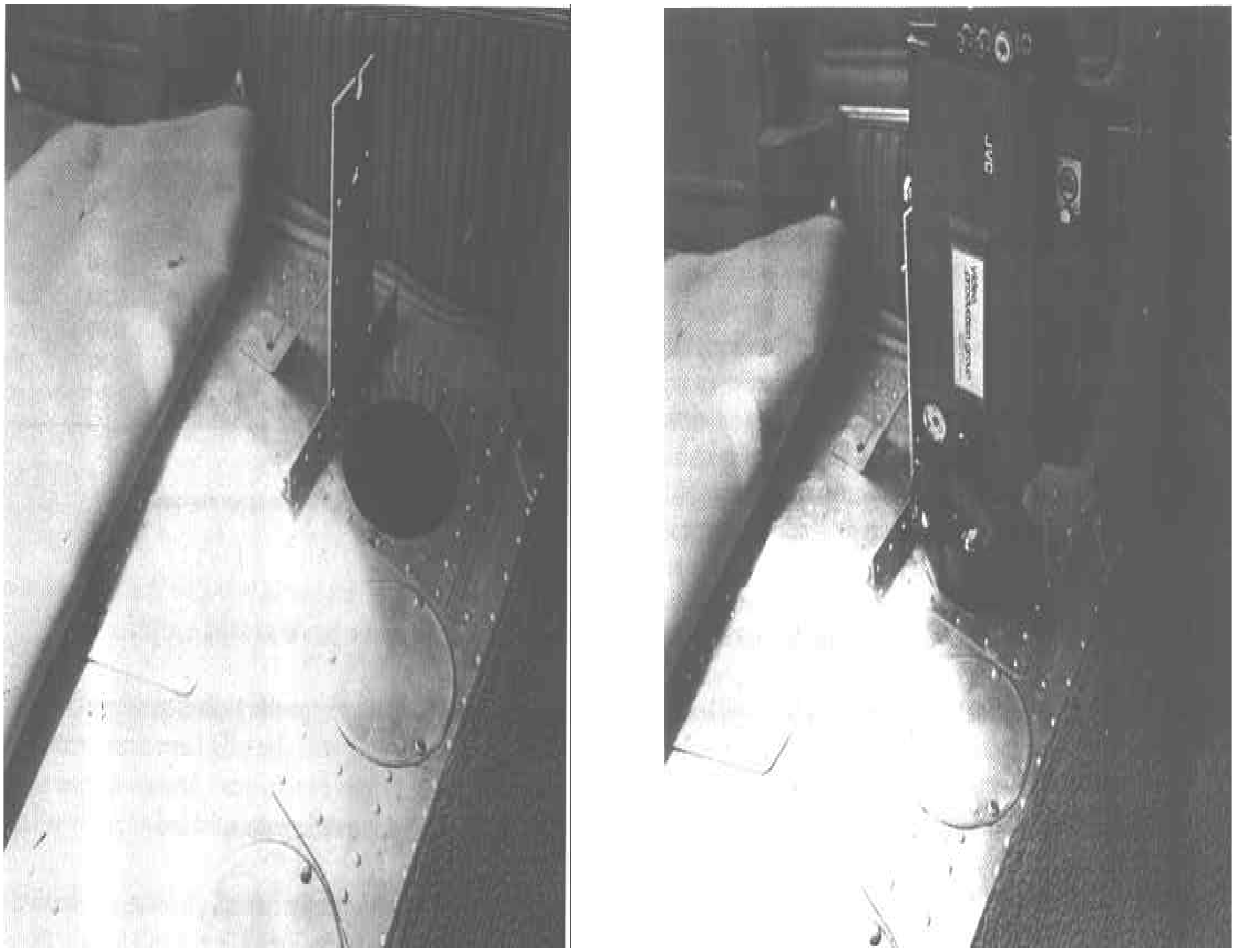
Figure 16-6. Generalized video equipment setup in an aircraft for vertical aerial videotaping (after Meisner 1986)

(2) Video monitors display the video image. Portable monitors generally have a 12.7-centimeter (5-inch) diagonal screen, providing a 7.6 × 10.2-centimeter (3 × 4-inch) image, although color monitors as small as 6.6 centimeters (2.6 inches)(screen size of 4.1 × 5.3 centimeters [1.6 × 2.1 inches]) are available and may be useful for airplane cockpit mounting. The video monitor must be located within the pilot's view to provide feedback for positioning and control of the aircraft. A sun shield on the monitor screen is essential for in-aircraft use. Interpretation in the office can be done with the portable monitor, but a larger screen is preferable.

(3) Power supply should be taken from the aircraft if possible. Airplanes operating on 12 volts should be able to power the system directly through the cigarette lighter outlet. Larger planes operate on 24-volt systems, requiring a dc adaptor to directly power the video system. Alternatively, power can be obtained from built-in, rechargeable battery packs or a rechargeable, sealed, lead–acid battery (gel cell).

(4) The playback video system used for interpretation in the office following the flight should have fast-motion, slow-motion, and still-frame capabilities. Of these, the still-frame (or freeze-frame) is the most important, since a single frame must be displayed if actual mapping is done during interpretation. The still-frame must be free from noise bars and hold steady on the screen. A playback VCR with stereo audio tracks is useful. This allows one track to be used for in-flight annotation, the other track for later interpretation comments.

d. Taking videotapes (Maggio and Baker 1988, Meisner 1986). The blur problem caused by aircraft vibration can be solved by properly mounting a video camera on the floor of an aircraft for taping through a port (Figure 16-7). Districts should be sure that contractors taking vertical videotapes have a mount that has been tested and proven to work. Forward-looking mounts would be useful for providing improved navigational assistance to the pilot. Forward-looking video also improves the ability to locate the imagery during interpretation. The background of each frame will show a wide area, giving more landmarks, while the foreground will provide larger scale for interpretation. Since whatever appears at one time in the background will later appear in the foreground, the continuous coverage nature of video imagery helps in this case. Even in applications requiring vertical coverage, a selectable forward



a. Camera mount and viewing port **b. Camera in place for vertical videotaping**

Figure 16-7. Simple video camera mount in the floor of an aircraft for through-a-port videotaping

inclination would be very useful for navigating up to the start of a flight line. The camera could be tilted forward on the approach to the line, and returned to the vertical position at the start of the line.

e. Tape interpretation. In addition to the portable equipment used during tape acquisition in an aircraft, and a monitor for office use, some additional hardware can be useful when viewing the tapes in the office. The importance of a high quality still-frame capability has already been mentioned. High quality, four-head VCR's can provide a more steady image than compact portable units and may be worth obtaining for interpretation use. The best still-frame images are provided by a digital freeze-frame unit, also called a frame-grabber. Such a device converts a frame of imagery to digital data, stores it in computer memory, and regenerates a video image from the stored data. Unfortunately, these devices are quite expensive. Good quality prints, slides, and film negatives can be made directly from videotapes with a Polaroid Frame Grabber. As with 35-mm photographs, almost everyone has looked at videotapes, and the most important element in interpretation is to have a person who knows river ice, and has observed and studied it, be involved in the video image interpretation.

16-11. Ground-Based Video

a. Normal speed. Video systems consisting of battery-operated portable cameras and recorders, or combined camcorders, can be used to document ice conditions and other problems along a river. Rock Island District has supplied the lockmasters with these devices and is using them to document both wintertime and summertime problems. Such problems may be ones calling for special maintenance attention, ones suggesting operational or structural modifications, or ones that can potentially lead to litigation. These video systems are attractive because of the instant documentation that is available and the low cost of operation. When using a video camera for documentation, it is helpful to remember the following points. Known problem areas should be regularly documented, preferably from the same vantage point. A tripod should be used whenever possible to minimize motion in the picture. And finally, deliberate movement of the camera or lens (panning and zooming) should be minimized, and if done, done slowly.

b. Time-lapse. When a River Ice Management Plan is being developed and a problem area has been identified, it is desirable to obtain a complete record of observations of ice problems at that problem location throughout the winter. These problems are often concentrated at the upstream approaches of the locks, where broken ice becomes lodged, adversely affecting the operation of lock gates and the movement of tow traffic. Time-lapse videography permits the collection of an extensive record of these conditions without having personnel occupying the site continuously for the entire ice season. Time-lapse videography can be used to determine the causes of specific ice problems at a location or to monitor the effectiveness of ice control solutions. Time-lapse videography has been used successfully on the Ohio and Illinois rivers both to determine the causes of ice problems and to monitor the effectiveness of ice control measures at locks, such as high-flow air systems. At Emsworth Lock and Dam on the Ohio River near Pittsburgh, Pennsylvania, time-lapse videography has been used to observe the effects of winds, currents, and large tow traffic on ice movement into the upper lock approach since the winter of 1984–85. At Peoria Lock and Dam on the Illinois River near Peoria, Illinois, and at Starved Rock Lock and Dam on the Illinois River near Ottawa, Illinois, data have been recorded on the effects of winds, river currents, and large tow traffic on the movement of ice in the upper lock approaches. In addition, the effectiveness of high-flow air screens was monitored at the latter two sites. The time-lapse videographic records at Peoria have been taken annually since the winter of 1984–85, while records from Starved Rock are available since 1985–86. In addition to wintertime uses, various Corps facilities—e.g., Starved Rock Lock and Dam in Illinois and Lower Granite Lock and Dam on the Snake River in Washington—are using video cameras to monitor recreational boating, commercial navigation, debris control, and general facility security.

(1) Equipment. There are two general types of time-lapse setups that are available today, time-lapse photographic film cameras and time-lapse VCRs. Of the two, the VCR system is preferable (it is easier to work). While the initial cost of both systems is comparable, the VCR system is substantially cheaper to operate. The minimum equipment required for an ice monitoring time-lapse videographic system consists of the following:

- Time-lapse recorder with recording time ranges of 2 to 240 hours and monitor.

- Solid state imaging video-camera and zoom lens with a focal length range of 10–100 mm.

- Environmental camera housing capable of maintaining an interior temperature of 4.4°C (40°F) while the ambient air temperature can be as low as –51°C (–60°F). The camera housing should be mounted on a remotely controlled pan and tilt mount.

- Remote controllers for the pan–tilt mount and the zoom lens.

- Miscellaneous equipment such as mounting brackets, cables, relay boxes, etc., that may be required for a specific site.

(2) Installation. The camera is best installed in a high location, such as an antenna mast or the craneway over the dam gates. The VCR and various controllers should be located in a protected shelter where it is convenient to monitor the video and to change tapes. At a lock facility, this can be the lockmaster's office or one of the machinery buildings. The main requirements here are that the humidity be low enough that condensation does not form and the temperature be kept between 4.4 and 38°C (40 and 100°F). Figure 16-8 is a schematic of a typical installation. The problems encountered in placing cables for the controllers and the video signal may influence the choices for placing the equipment.

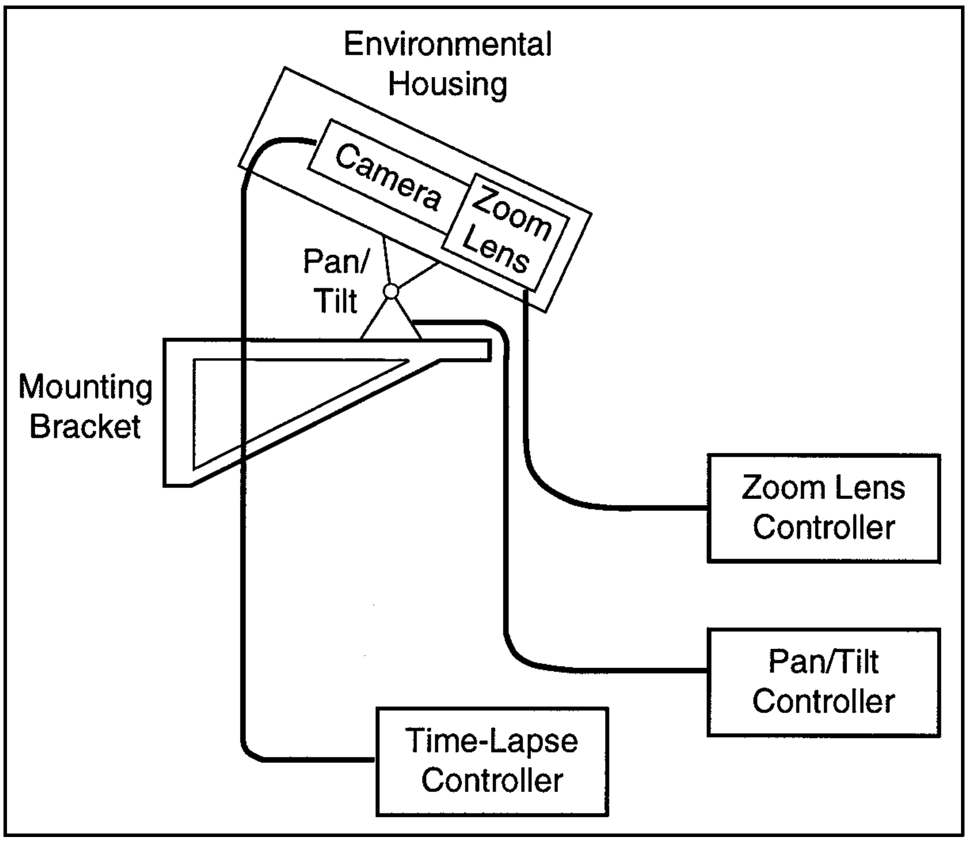


Figure 16-8. Schematic diagram of a ground-based time-lapse video system

16-12. References

a. Required publications.
None.

b. Related publications.

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